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Bryozoa of the southern Caspian Sea, Iranian coast

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Abstract
Bryozoans were found attached to various natural and artificial substrates at 18 sites along the Iranian coast of the southern Caspian Sea. Two species of cheilostome bryozoans—*Conopeum grimmi* and *Lapidosella ostroumovi*—and 2 species of ctenostomes—*Amathia gracilis* and *Victorella pavida*—are reported. *Lapidosella ostroumovi* is a new record for the Caspian Sea.

Key words
Cheilostomes; ctenostomes; Iranian coast; new record.

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Introduction

Studies on Caspian Sea bryozoans have been done mostly in the northern Caspian (Abrikosov 1959, Abrikosov and Zevina 1968, Gontar et al. 2009). The fauna of bryozoans in the Caspian Sea comprises species belonging to the classes Phylactolaemata and Gymnolaemata, including representatives of both orders Cheilostomatida and Ctenostomatida. High levels of endemism have been detected that can be explained by the low salinity and long-term isolation of the Caspian Sea (Gontar 2013). Seven species have been reported: the freshwater bryozoans *Paludicella articulata* (Ehrenberg, 1831) and *Plumatella emarginata* Allman, 1844, and the brackish/marine species *Conopeum seurati* (Canu, 1928), *C. grimmi* Gontar & Tarasov, 2009, *Amathia imbricata caspia* (Adams, 1798), *Amathia gracilis* (Leidy, 1855) and *Victorella pavida* Saville-Kent, 1870. Bryozoans in the Caspian Sea can be subdivided into: (1) freshwater species; (2) Caspian Sea endemic species; (3) Mediterranean–Caspian species; and (4) Mediterranean species that have recently been introduced into the Caspian through the Volga–Don Canal (Abrikosov and Zevina 1968). Here, for the first time, we report the occurrence and distributions of 4 species of bryozoans from the Iranian coast of the Caspian Sea. We also test their potential preferences for different substrate types.

Methods

Cheilostome bryozoans attached to stones, plastic debris, wood, glass and other objects washed-up on the beach or from shallow water (< 1 m depth) were collected from 18 sites along the Iranian coastline of the southern Caspian Sea (Fig. 1, Table 1). Specimens were bleached using sodium hypochlorite solution (5.2%), air-dried and coated with gold prior to scanning electron microscopy using a Hitachi SU3500. To study the ctenostome bryozoans, a series of PVC panels were deployed at 1 m depth in the port of Astara (38°25′26.80″ N, 048°52′45.70″ E).

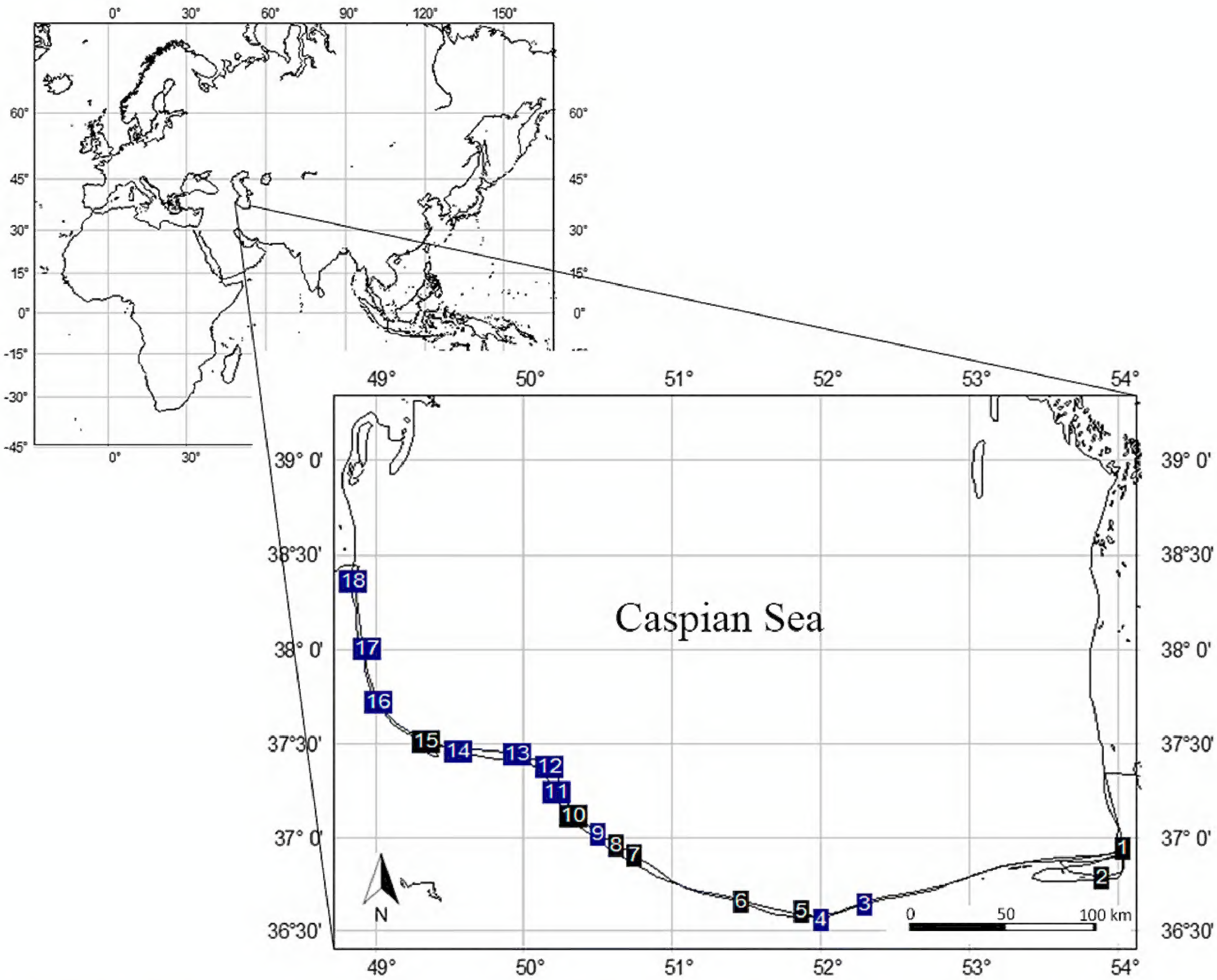

Figure 1. Map of the sampling sites (rectangles), southern Caspian Sea, Iran; 1: Bandar Torkaman; 2: Bandar Gaz; 3: Mahmudabad; 4: Nur; 5: Sisangan; 6: Chalus; 7: Ramsar-1; 8: Ramsar-2; 9: Chaboksar; 10: Kelachay; 11: Rudsar; 12: Dastak; 13: Kiashahr; 14: Hasan Rud; 15: Bandar-e Anzali; 16: Khalifabad; 17: Haviq; 18: Astara. The blue rectangles indicate the locations of the new record. Maps were made using freeware tool PanMap.

Live specimens on the panels were then transferred to the lab and photographed in seawater using a digital camera (Canon G12) and a Dino Capture, both mounted on a stereoscopic microscope (Leica, WILD M8). All specimens are stored in the Marine Ecology Laboratory of Shahid Beheshti University, Iran (MELSB).

Table 1. Location and geographic coordinates of bryozoan sampling sites in the southern Caspian Sea.

Station no.	Location	Latitude	Longitude
1	Bandar Torkaman	36°53′47.94″N	054°02′31.45″E
2	Bandar Gaz	36°47′17.10″N	053°56′30.10″E
3	Mahmudabad	36°38′10.70″N	052°15′37.50″E
4	Nur	36°34′38.70″N	051°59′51.60″E
5	Sisangan	36°34′41.40″N	051°49′42.51″E
6	Chalus	36°40′58.66″N	051°26′04.63″E
7	Ramsar-1	36°55′34.10″N	050°40′10.90″E
8	Ramsar-2	36°56′40.30″N	050°38′46.30″E
9	Chaboksar	36°58′25.30″N	050°34′54.50″E
10	Kelachay	37°04′56.10″N	050°23′42.22″E
11	Rudsar	37°12′48.24″N	050°16′27.62″E
12	Dastak	37°22′45.73″N	050°11′57.23″E
13	Kiashahr	37°26′30.88″N	049°57′48.96″E
14	Hasan Rud	37°27′34.70″N	049°39′29.56″E
15	Bandar-e Anzali	37°28′50.92″N	049°27′21.53″E
16	Khalifabad	37°43′01.88″N	049°0′52.81″E
17	Haviq	38°06′03.85″N	048°54′55.15″E
18	Astara	38°25′26.80″N	048°52′45.70″E

Results

Order Cheilostomata Busk, 1852
Suborder Malacostega Levinsen, 1902
Superfamily Membraniporoidea Busk, 1854
Family Electridae d'Orbigny, 1851
Genus *Lapidosella* Gontar, 2010

Lapidosella ostroumovi Gontar, 2010: Figure 2A–F

Material examined. MELSB-38, Station 3, on stone, February 17, 2016; MELSB-56, Station 4, on stone, February 17, 2016; MELSB-110, MELSB-112, Station 9, on wood, February 20, 2016; MELSB-121, Station 11, on glass bottle, February 21, 2016; MELSB-125, Station 12, on stone, February 21, 2016; MELSB-146, Station 13, on stone, February 21, 2016; MELSB-149, Station 14, on plastic bottle, February 21, 2016; MELSB-176, Station 16, on stone, February 22, 2016; MELSB-182, Station 17, on stone, February 22, 2016; MELSB-198A, MELSB-198B, MELSB-199, Station18, on plastic bottle, February 22, 2016.

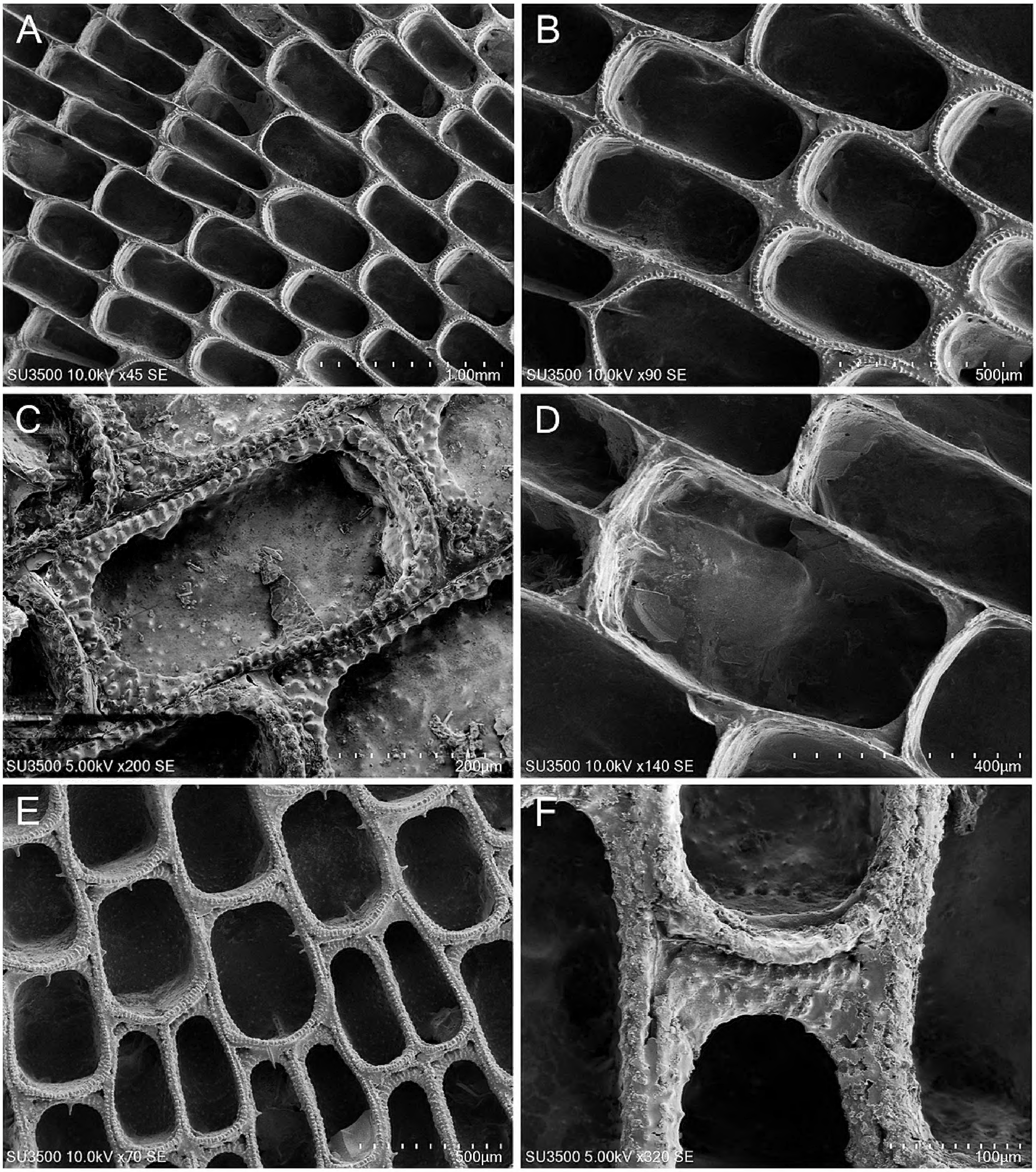

Figure 2. *Lapidosella ostroumovi*. **A.** Portion of a colony showing rectangular autozooids. **B.** Close-up of some autozooids. **C.** Close-up of an autozooid. **D.** Close-up of a wide, "Doppelgänger" autozooid with two opercula preceding a row bifurcation. **E.** Part of colony showing some autozooids with proximal spinules (distal is downwards). **F.** Close-up of a vertical wall showing uniporous mural septulae (distal is downwards). (A, B, D, E: MELSB-199; C: MELSB-121; F: MELSB-198A.)

Description. Colony white, growing on various substrates, a few centimetres in diameter, initially encrusting and unilaminar, becoming erect and bifoliate. Autozooids subrectangular to rectangular and irregularly elongated in shape, arranged in rows, 0.43–0.66 mm long by 0.17–0.37 mm wide, distal edge rounded and proximal edge concave. Opesia oblong-oval in shape, occupying almost entire frontal surface. Cryptocyst a very narrow rim, covered with tubercles. Cryptocystal spinules present or absent, up to 3 pairs located proximally. Gymnocyst absent. Lateral walls well-calcified, translucent in young autozooids. Operculum transparent, uncalcified, with rounded distal and straight proximal edge. Closure plates not observed. Ovicells and avicularia absent. Transverse walls with a row of uniporous mural septulae.

Remarks. Gontar (2010) originally erected the genus *Lapidosella* for *Lapidosella ostroumovi* from the Sea of

Azov. According to Gontar (2010) this species was been first found there by Ostroumov in 1891 but misidentified as *Membranipora reticulum*. The present study gives the first record of *Lapidosella ostroumovi* from the Caspian Sea. Gontar (2010) noted that autozooids in specimens from the Sea of Azov were about 0.35–0.57 mm long by 0.22–0.39 mm wide. In comparison with Gontar's Sea of Azov material, autozooids of the present material are generally longer and narrower.

According to Gontar (2010), *Lapidosella* differs from other genera of the family Electridae in the absence of a gymnocyst, having cryptocystal opesial spines, budding pattern of autozooids (which is distal and leads into 1 or 2 daughter autozooid), and colony formation. *Biflustra sphinx* Vieira, Almeida & Winston, 2016 resembles *L. ostroumovi* in autozooidal shape and budding pattern and in having uniporous mural septulae in the vertical walls, but *L. ostroumovi* is distinguished by having cryptocystal spines, while gymnocystal tubercles are present in *B. sphinx* but absent in *L. ostroumovi*.

Opercula of *L. ostroumovi* differ from those of *Conopeum seurati* in which a folded membranous structure occupies their periphery. In *L. ostroumovi*, the cryptocyst is a narrow rim covered with tubercles, while the cryptocyst of *C. seurati* consists of notches that can be simple festoons or pointed spinules. Gymnocyst is absent in *L. ostroumovi* but present in *C. seurati* (Gontar 2010).

Autozooids of *L. ostroumovi* become longer and their walls thinner near the edges of the colony. Younger autozooids have thinner, common walls, which indicate the early ontogenetic state. This actually explains the reason of different appearance of autozooids in this species.

Distribution. World: Sea of Azov (Gontar 2010); Iran: Mazandaran and Guilan provinces (present study).

Genus *Conopeum* Gray, 1848

Conopeum grimmi Gontar & Tarasov *in* Gontar et al. 2009: Figure 3 A–F

Material examined. MELSB-1, Station 1, on stone, February 16, 2016; MELSB-17, Station 2, on stone, February 16, 2016; MELSB-46, Station 3, on stone, February 17, 2016; MELSB-64, Station 5, on stone, February 17, 2016; MELSB-70, Station 6, on stone, February 17, 2016; MELSB-82, Station 7, on stone, February 20, 2016; MELSB-96, Station 8, on stone, February 20, 2016; MELSB-114A, MELSB-114B, Station 9, on metal can, February 20, 2016; MELSB-115, Station 10, on glass bottle, February 20, 2016; MELSB-145, Station 13, on stone, February 21, 2016; MELSB-151, Station 14, on stone, February 21, 2016; MELSB-158, MELSB-156, Station 15, on stone, February 22, 2016; MELSB-171, Station 16, on stone, February 22, 2016; MELSB-189, Station 17, on stone, February 22, 2016; MELSB-199, MELSB-197, Station 18, on plastic bottle, February 22, 2016.

Description. Colony growing on various substrates, white, encrusting, unilaminar or multilaminar, zooids arranged uniserially, biserially and mostly multiserially, developing regular sheets on even surfaces and becoming irregular on uneven surfaces, diameter measuring a few centimetres. Autozooids elongated oval with rounded distal edges, irregular in shape in the colonies formed on uneven substrata, 0.35–0.69 mm long by 0.15–0.32 mm wide, often arranged in oblique and disordered rows. Cryptocyst narrow, covered with tubercles. Pointed spinules present in a minority of zooids, up to 5 pairs. Gymnocyst narrow, mostly developed proximally. Opesia occupying almost entire frontal surface. Operculum impressed on closure plates of some zooids. Ancestrula smaller than later autozooids, lacking spines, budding 1 daughter zooid distally and 1 proximally. Lateral vertical walls containing at least 2 communication pores. Kenozooids and intramurally budded autozooids present.

Remarks. According to Zevina (1967), *Conopeum seurati* is the most abundant species in the Sea of Azov, as well as the first bryozoan species to have been discovered in the Black Sea. She also pointed out that this species was confused in the past with *Electra crustulenta* (Pallas, 1766) and *Conopeum reticulum* (Linnaeus, 1767). *Conopeum seurati* was reported in the Caspian Sea by Zevina (1959) who claimed that it penetrated into the Caspian through the Volga–Don Canal from the Black Sea or the Sea of Azov. Zevina and Kuznetsova (1965) distinguished 3 forms (morphs) of *C. seurati*. Gontar (2010) restudied the Caspian Sea collections of Zevina in the Zoological Institute of the Russian Academy of Sciences, subsequently interpreting all of the bryozoans as *C. grimmi* and mentioning that true *C. seurati* has not been observed in the Sea of Azov or the Caspian Sea (Gontar 2013). However, Riedel et al. (2006) reported *C. seurati* from the Caspian Sea. This species has also been reported from Black Sea (Gontar 2014) and may have been transported through Volga–Don canal to the Caspian, contradicting Gontar (2013). Gontar et al. (2009) described *C. grimmi* from Salyanskyraid in the southern Caspian Sea as characterized by uncalcified opercula, autozooids about 0.45–0.65 mm long by 0.20–0.25 mm wide, and up to 3 pairs of distal spinules oriented almost perpendicular to the frontal surface of the autozooid. The present material from Iran shows a greater variability in the size of autozooids and up to 5 pairs of spinules.

Closure plates ('kleistozooids') can be observed in both *Conopeum seurati* and *C. grimmi*. Opercula of *C. grimmi* differ from those of *C. seurati* in which a folded membranous structure occupies the periphery. The ancestrula of *C. seurati* has 1 pair of distal spines, while there is no spine in the ancestrula of *C. grimmi*. In *C. grimmi*, cryptocyst is covered with tubercles, while the cryptocyst of *C. seurati* consists of notches that can be simple festoons or pointed spinules. The gymnocyst of *C. seurati* may have a variable number of large outgrowths, which are absent in *C. grimmi*. *Conopeum grimmi* and *C. reticulum* have different early astogenetic growth patterns. Development of the colony begins with distal and

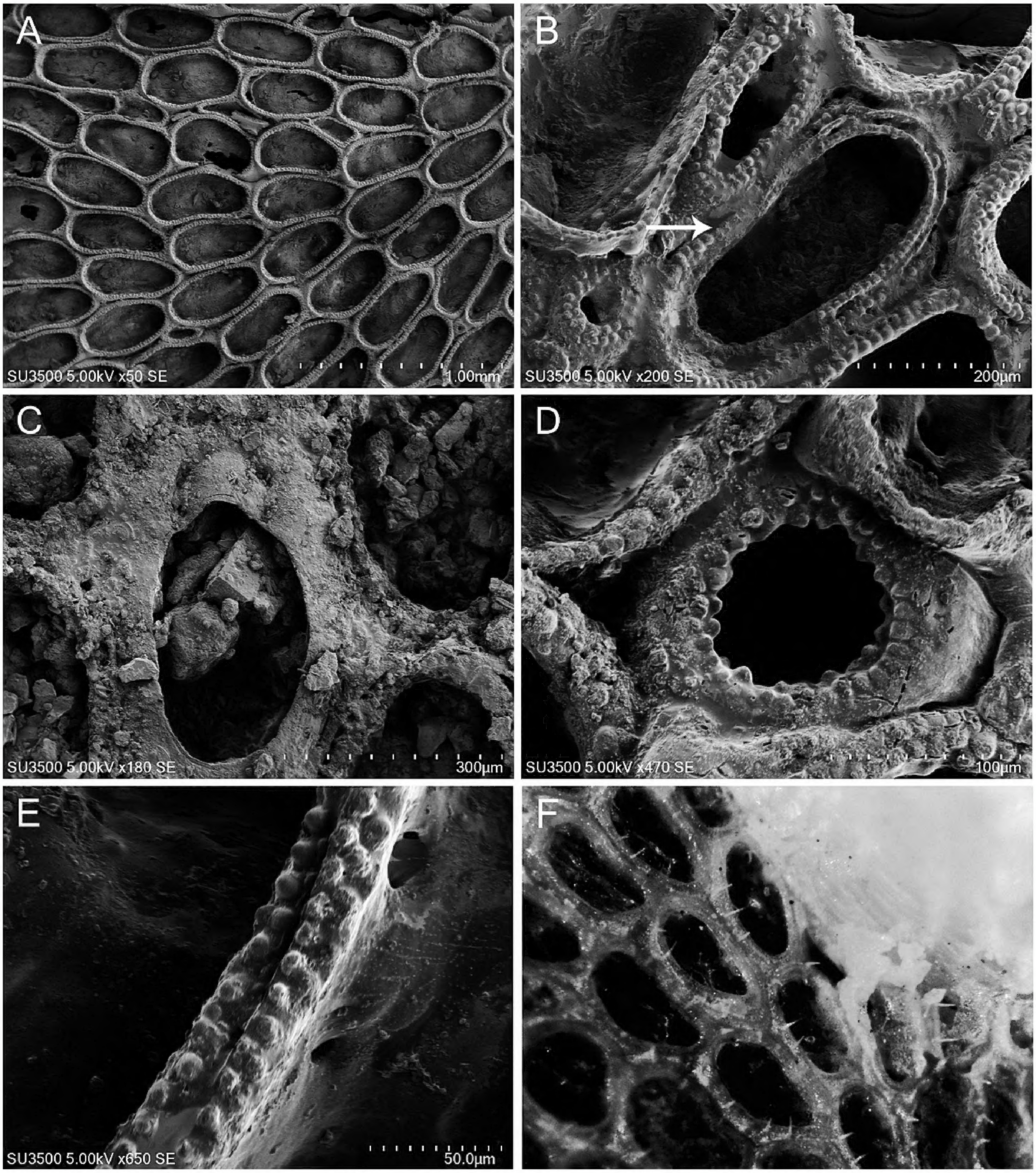

Figure 3. *Conopeum grimmi*. **A.** Part of a colony. **B.** Kenozooids and an autozooid hosting an intramural bud (arrow indicates the intramurally budded autozooid). **C.** Close-up of an autozooid with partial closure plate bearing indentation of the operculum. **D.** A kenozooid. **E.** Lateral walls with two communication pores. **F.** Optical image of a colony showing autozooidal spinules. (A: MELSB-156; B: MELSB-17; C: MELSB-82; D: MELSB-70; E: MELSB-158; F: MELSB-197.)

proximal budding from the ancestrula in *C. grimmi*, while budding from the ancestrula is disto-lateral and proximal in *C. reticulum*. *Conopeum reticulum* has a pair of distal kenozooids not seen in this constant pattern in either *C. grimmi* or *C. seurati* (Gontar et al. 2009).

Distribution. World: Salyanskyraid from the southern Caspian Sea; middle and northern Caspian Sea (Gontar et al. 2009); Iran: Golestan, Mazandaran and Guilan provinces (present study).

Order Ctenostomata Busk, 1852
Suborder Vesicularina Hincks, 1880
Superfamily Vesicularioidea Hincks, 1880
Family Vesiculariidae Hincks, 1880
Genus *Amathia* Lamouroux, 1812

Amathia gracilis (Leidy, 1855): Figure 4 A–E

Material examined. MELSB-202, Station 18, on PVC panels (immersion periods of 2 and 11 months), August 10, 2016.

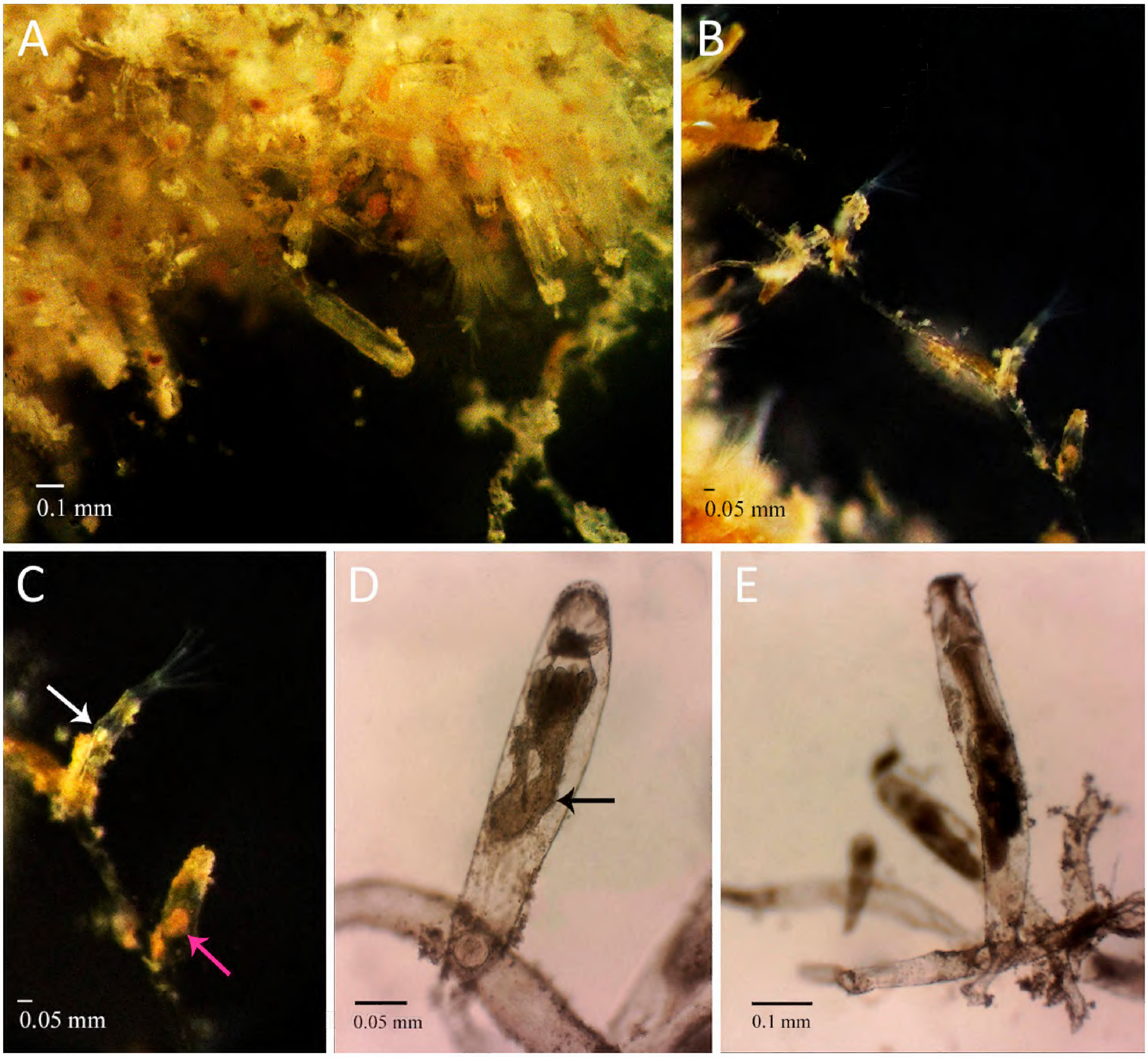

Figure 4. *Amathia gracilis*. **A.** Dense colony. **B.** Autozooids oriented in various directions on a slender stolon. **C.** Close-ups of autozooids; the white arrow indicates a yellow egg and the pink arrow shows a pink embryo within an autozooid. **D.** Autozooid, with arrow pointing to the gizzard. **E.** Autozooids with tail-like outgrowths in the basal part. (A–E: MELSB-202.)

Description. Colonies transparent or pale yellow, encrusting, diffuse or creating dense clumps. Autozooids tubular, 0.39–0.92 mm long by 0.07–0.13 mm wide, attached to the stolon, oriented in various directions. Stolons narrower than autozooids, about 0.05 mm wide, branching, divided by interior septa. Long tail-like outgrowths at the ends of some autozooids. Polypides with 8 tentacles, transparent. Embryos relatively large, pink, visible inside the body cavity. Eggs pale yellow.

Remarks. The phylogeny of Vesiculariidae has been recently studied using molecular methods (Waeschenbach et al. 2012, 2015). This led to *Bowerbankia* and *Zoobotryon* being synonymized with *Amathia*. *Amathia gracilis* was first described from the eastern United States (Leidy 1855, Hayward 1985). It resembles other species of the genus *Amathia*, including *A. maxima* from which it differs in the absence of white pigment on the tentacles, at the base of the lophophore and inside the zooid and stolon, and in being significantly smaller (Winston 1982).

Distribution. Cosmopolitan.

Suborder Victorellina Jebram, 1973
Superfamily Victorelloidea Hincks, 1880
Family Victorellidae Hincks, 1880
Genus *Victorella* Saville-Kent, 1870

Victorella pavida Saville-Kent, 1870: Figure 5 A–C

Material examined. MELSB-202, Station 18, on PVC panels, (immersion periods of 2 and 11 months), August 10, 2016.

Description. Colony yellow, encrusting, developing diffuse branching stolons or dense clumps of zooids. Autozooids elongate, cylindrical, varying in shape and size, 0.40–1.40 mm long by 0.09–0.16 mm wide, proximal part adnate. Polypides with campylonemidan lophophore

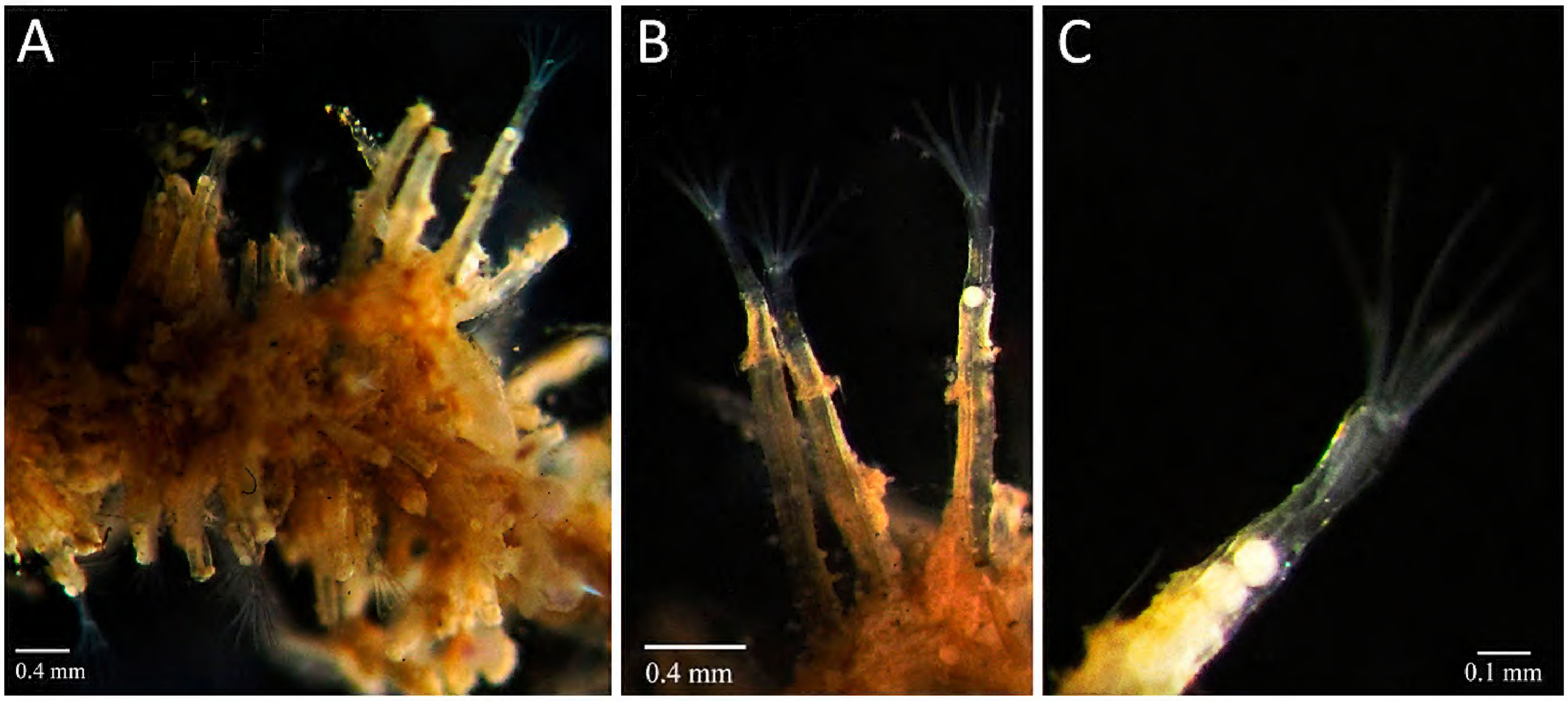

Figure 5. *Victorella pavida*. **A.** Dense colony showing autozooids of varying sizes. **B.** Three autozooids with extended lophophores. **C.** Close-up of an autozooid showing yellow eggs inside the body cavity. (A–C: MELSB-202.)

of 8 tentacles. Eggs white or pale yellow, up to 4 observed in brooding autozooids.

Remarks. *Victorella pavida* was first described from London, England in 1870 by Saville Kent. Abrikosov (1959) believed that *Victorella* was an indigenous representative of the Caspian Sea and of the Sea of Aral. The species seems widespread in the Ponto-Caspian region (Zevina, 1967). Mordukhay-Boltovskoy (1964) considered that *V. pavida,* along with the hydroid *Cordylophora caspia,* reached American localities from the Caspian Sea. Other studies have reported the presence of these species together (Wasson et al. 2000). It is interesting to note that *V. pavida* was also found entangled with a hydroid in samples collected for the present study.

Distribution. Probably cosmopolitan.

Discussion

The Caspian Sea is the largest lake in the world and contains brackish water (Karpinsky 1992, Dumont 1998, Aladin and Plotnikov 2004). Salinity increases from the north to south, with the average value being 12.85 g/l (Aladin and Plotnikov 2004). The low salinity and long-term isolation of this lake created suitable conditions for only a few inhabitants, among which are a small number of bryozoan species (Karpinsky 2005). The Black, Azov and Caspian seas (Ponto-Caspian Basin) were separated and reconnected several times during geological history, and construction of Volga–Don shipping canal caused anthropogenic reconnection of these seas in 1952 (Grigorovich et al. 2002, 2003, Riedel et al. 2006, Panov et al. 2007, Shiganova 2010).

Gontar (2010) described a new cheilostome species, *Lapidosella ostromuovi*, from the Sea of Azov. In the present study, we have recorded this species in the Caspian Sea for the first time. It may have entered the Caspian from the Sea of Azov via the Volga–Don Canal only recently, or it may have persisted in the Caspian from the time when these 2 water bodies were once connected, remaining undetected until now.

Conopeum is a widespread genus with 2 species reported from the Caspian Sea. *Conopeum seurati* is an invasive species from the Mediterranean Sea that penetrated in the 1950s from the Black Sea and Sea of Azov (Aladin et al. 2002, Grigorovich et al. 2003, Zonn et al. 2010), whereas *Conopeum grimmi* can be considered as an indigenous species.

According to Abrikosov (1959), species of the genus *Amathia* (reported as *Bowerbankia*) in the Ponto-Caspian basin area (Caspian Sea, Black Sea, Sea of Azov and Aral Sea) should be regarded as invasive species from the west. *Amathia imbricata* apparently penetrated naturally via the Kumo-Manycheskiy Strait about 50,000 years BP (Aladin et al. 2002, Mamaev 2002, Grigorovich et al. 2003). In the Caspian Sea, it is represented by the subspecies *A. imbricata caspia*. *Amathia gracilis* is a euryhaline species that can tolerate a wide range of salinities (Winston 1977). This species is probably cosmopolitan and occurs in several biogeographical regions of the world (Winston 1977, Gordon and Mawatari 1992, Cognetti and Maltagliati 2000, Wolff 2005).

Victorella pavida is a euryhaline and cosmopolitan species, and can be found in brackish and fresh waters (Bousfield 1885, Everitt 1975, Winston 1977, Poirrier and Mulino 1977, Sammarco 1982, McCann et al. 2007). In this study, *V. pavida* and *A. gracilis* were observed on the same panels, with their colonies intertwined. At first glance, they are very similar and difficult to distinguish because of some common characters, such as yellow eggs inside the zooids and number of tentacles. However, *V. pavida* has an obliquely truncated (campylonemidan) lophophore whereas the lophophore of *A. gracilis* has tentacles of equal length.

In total, this study identified 2 cheilostome and 2

ctenostome species. Among these, *L. ostroumovi* represents a first record for the Caspian Sea. The 2 cheilostome species showed no affinities for particular substrates, both being present on the surfaces of various types of substrates. Although we sampled both dry and wet materials from the shoreline and underwater areas (to a depth of about 1m) for bryozoan species, more and continuous monitoring should be carried out to detect any introduced species, especially in the context of climate change.

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Authors' Contributions

SMK collected the data, contributed to the identification and wrote the first draft of the manuscript. AN and PDT contributed to the identification and writing of the manuscript. BA helped in identification and also financial support.

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